Destruction of renal parenchyma at percutaneous nephrolithotripsy; experimental study

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DESTRUCTION OF RENAL PARENCHYMA AT PERCUTANEOUS NEPHROLITHOTRIPSY ; EXPERIMENTAL STUDY

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The destruction of renal parenchyma caused by excess deflection of the sheath was examined to determine at what level of force the renal parenchyma was ruptured during PNL. The kidney obtained from right nephroureterectomy due to renal pelvic cancer (stage $T_2N_0M_0$) of a 54-year-old female patient was punctured at the posterolateral portion with a puncture needle. The tract was dilated up to 26 Fr. in size with an Amplatz renal dilation set. The 26 Fr. sheath was left in the tract and fixed to the metal bar attached to Gig Boring Machine (Hydroptic-6) which could sense the change of pressure added to the renal parenchyma in the parallel movement of the metal bar. The critical angle in regard to the deflection of the renal parenchyma in order not to cause the rupture of renal parenchyma on PNL was calculated from both the resultant force and the shape of the wound of renal parenchyma at rupture. The safety angle against holizontal plane of the tract ranged from 18 to 37 degree.

Key words: Destruction of renal parenchyma, PNL, Experimental study

INTRODUCTION

Percutaneous nephrolithotripsy (PNL) is now widely applied for the treatments of both renal and ureteral stones. One of the major complications in PNL is massive renal bleeding which often necessitates transfusion in this new technique for urolithiasis due to renal parenchymal disruption[1,2]. Massive renal bleeding is thought to occur by an excess of deflection of the sheath of the tract in order to catch the stone in the endoscopical vision.

Experimental study of the destruction of renal parenchyma by excess deflection of the sheath was performed to determine at what level of force renal parenchyma was ruptured.

MATERIALS AND METHODS

The kidney was obtained at right nephrectomy on Dec 17, 1987 due to right renal pelvic cancer (stage $T_2N_0M_0$) in a 54-year-old female patient. It was put into ice cold PRMI medium as soon as the kidney was removed at the operation. The kidney was brought to the Osaka Prefectural Industrial Research Institute 4 hours later and back to room air temperature in warm saline. The patient did not have any other diseases such as diabetes mellitus, tuberculosis, glomerulonephritis, and pyelonephritis which may have caused fragility of renal parenchyma.

The kidney was punctured with a 14 gauge needle at the posterolateral portion and the tract was dilated up to 24 Fr. using an Amplatz renal dilator set. A 24 Fr. sheeth was left in the tract which was fixed to the metal bar attached to a Gig Boring Machine (Hydroptic-6, Sip Company, Swiss) with tape (Fig. 1). The kidney with 26 Fr. sheath inserted was put in the box on the pressure sensor and fixed with tape. This pressure sensor senses the subtle change of pressure on both tangential and normal line direction in the parallel movement of the metal bar of hydroptic-6 at the speed of 0.2 cm/min against the vertical direction to the lower pole (Fig. 2). The change of pressure added to the renal parenchyma by the external force was recorded by the L cassette tape recorder FB38A (Sony, Japan) at the variance of the electrical voltage generated by the change of pressure via the crystals of quartz.

RESULTS

The solid line in Figure 3 shows the force of the tangential component and dotted line the force of normal line component. The resultant force of these two components reached 1.06 kgw at point A, when the resistance of power dercreased sharply and the renal capsule was found to be torn at lateral portion (Fig. 3).

The resistance of power decreased clearly at point B, where the resultant force reached 1.25 kgw, and where the renal parenchyma was found to be ruptured. The experiment was completed at point B. Just after the rupture of renal parenchyma was confirmed, the kidney was put into 10% formalin. Figure 4 shows the cut surface of the ruptured parenchyma after fixation.

DISCUSSION

The kidney moved against the added external force in a parallel and rotational way to prevent itself from parenchymal damage. In our experiment, the kidney was fixed in a box which could not be moved in a paralel way to the direction of movement of the sheath except some small parallel movement for the contraction of parenchyma in the range of the power of elasticity.

Figure 5 shows the estimated movement of kidney in this experiment under this restricted condition.

The renal parenchyma in the shaded area in Figure 4 was thought to be pulled by the external force. It is very important that the width of mid portion of the tract was not enlarged over 26 Fr. which meant that the external force added worked in a rotated way around the falcurum located in the mid points of the ruptured paren-

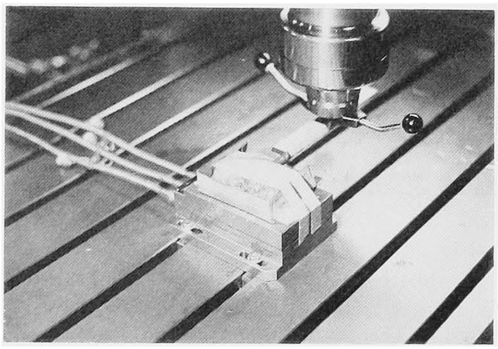


Fig. 1. The kidney was put in a box and 26Fr. Amplatz sheath was fixed to the metal bar of Gig Boring Machine.

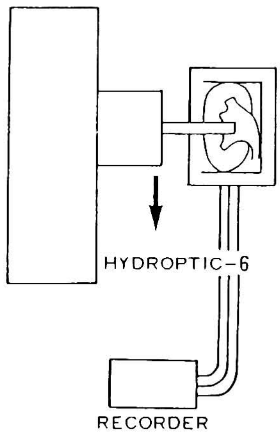


Fig. 2. The system of Hydroptic-6 (Gig Boring Machine). The arrow showed the direction toward which metal bar moved.

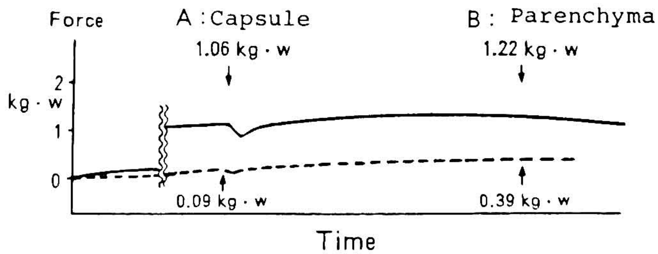


Fig. 3. Force at the rupture of both renal capsule (point A) and parenchyma (point B). Real line shows force at tangential direction and dotted line at normal line component.

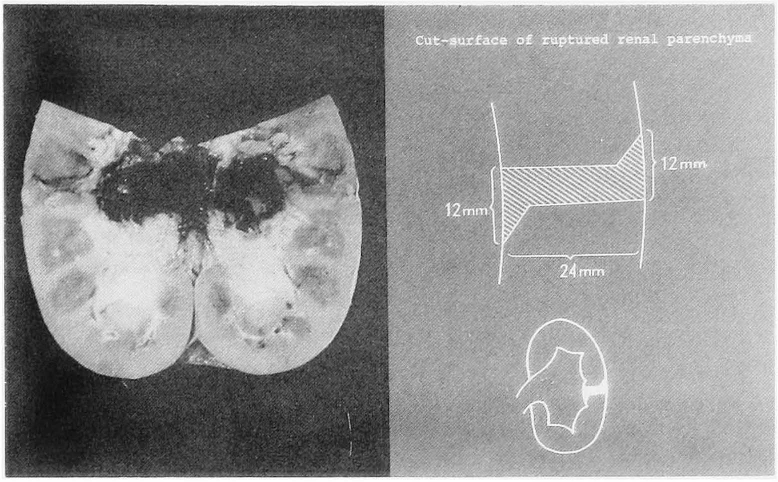


Fig. 4. Cut-surface of the ruptured parenchyma was shown.

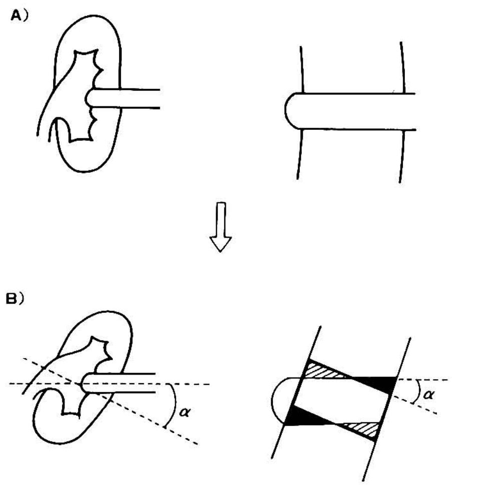


Fig. 5. Movement of the kidney against the external force.

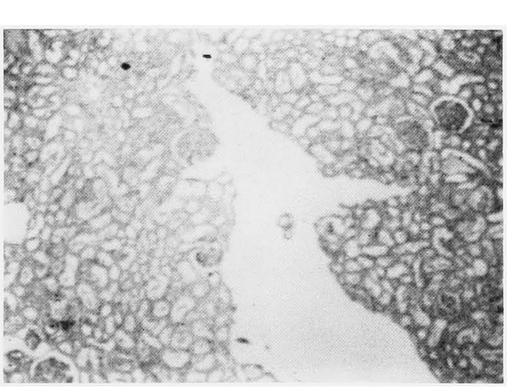
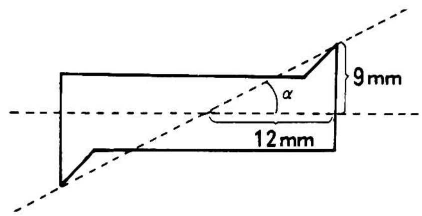


Fig. 6. Microscopical view of the cut surface of the ruptured parenchyma at the tip. (×200)



$$\alpha = \tan^{-1}\frac{9}{12} \approx 37°$$

Fig. 7. Critical angle to reach the rupture of renal parenchyma calculated from the ruptured shape.

chyma. The shape of the injury in the macroscopic observation of cut surface at the ruptured part was symmetrical in both lateral and renal pelvic sides. There was no enlarged tear observed to the direction over the tip of the macroscopic injury in the microscopic specimen (Fig. 6).

The critical angle α to reach the rupture of renal parenchyma was then calculated from the mesurement of ruptured shape which was approximately 37 degrees against the horizontal line (Fig. 6).

However, this angle may be overestimated for the tear is known to proceed over the point of rupture at its tip when the round form material proceeds in plastic matter. The resultant force was 1.28 kgw at the time of renal parenchymal rupture. Therefore, the kidney was thought to be deflected at 18 degrees

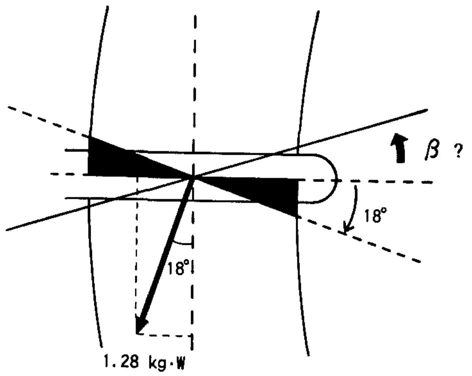


Fig. 8. Eighteen degrees were calculated from the resultant force at the time of renal parenchymal rupture. Angle β might be the angle corrected for the bending sheath to a certain degree by metal force. The real critical angle should be β plus 18 degree until renal parenchymal rupture by a external force.

against the vertical line in order not to have the rotation force (Fig. 8).

So we calculated that the renal parenchyma was ruptured by the external force when it was rotated at the angle of 18 degrees to vertical direction. However, at the 26 Fr. sheath was bent to a certain degree to the opposite direction of its movement, deflection angle of 18 degrees could be slightly under estimated.

In conclusion, the critical angle in regard to the safety deflection of the sheath not to cause renal parenchymal rupture on PNL under this restricted condition could range from 18 to 37 degrees against the horizontal plane of the tract. The safety zone of movement of the sheath could be enlarged in the actual procedure of PNL because of possible parallel movement of kidney in a certain range. Critical angle suggested by this experiment may be varied by the degree of hydronephrosis or the state of renal parenchyma caused by various kinds of renal diseases.

The experiment was only done in one kidney with normal parenchyma under restricted conditions. The experiment must be done in various conditions of renal parenchyma to confirm the safety range of deflection of the sheath on PNL.

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和文抄録

経皮的腎切石術における腎実質破壊の実験的研究

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PNL に際して，外筒を皮膚の刺入点を支点として様々な角度に回転させるとき，どの程度の角度で実質が破壊されるかを知るために，実験的検討を行った．右腎盂腫瘍（$T_2N_0M_0$）のため摘出された54歳女性の腎臓を用い，その外縁より腎盂に向かって穿刺した．次いで Amplatz 拡張器にてその経路を 26 F まで拡張した．そのまま 26 F の拡張器を留置し，それを治具中グリ盤（Hydroptic-6）の金属棒に固定した．この金属棒を腎下極に向かって平行移動させるとき，腎実質にかかる外力を測定し，その接線方向，法線方向それぞれの成分より腎実質が破壊された時の回転角を18度と推定した．また別に腎実質の破壊断面の形状より推定された角度は37度であった．従って今回の実験からは，PNL における外筒の法線方向に対する安全な回転角の上限は18度から37度の範囲と考えられた．

（泌尿紀要 **35**：1099-1103，1989）